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salinity, and density. That is to say, the waters have a gradual increase in density from the surface to the bottom, a gradual decrease in salinity from the surface to the bottom, and a gradual decrease in temperature from the surface to the bottom. But the details of the distribution of these quantities is unknown; of their variations from season to season and from year to year few observations have been made in the depths of the Pacific, and there is as yet very limited knowledge of the import of such changes upon the variations of climate and of physical and biological oceanography.

The observational foundation for investigating the ocean from the standpoint of thermodynamics requires the study in detail of definite stations occupied in concert and periodically revisited for the purpose of observing, as nearly as possible at the same time, such physical conditions, at certain depths, as the temperature, the salinity, the gas-content, and the currents; and in this way affording the means of presenting in the form of synoptic charts the changing network of lines of equal values of the physical elements in their distribution in the depths.

To sum up our thoughts, we may fix attention (1) upon the basin, of which no model can be at present constructed; (2) upon the deposits, whose thickness and stratification still remain unrevealed; (3) upon the waters, whose variations in physical conditions have not yet been sufficiently observed to explain the inner mechanism by which they operate to produce their effects in the economy of the earth.

MARINE METEOROLOGY AND THE GENERAL CIRCULATION OF THE ATMOSPHERE

By Charles F. Marvin

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Stations for the surface observation of meteorological conditions are now numerous in the principal civilized countries of the world, and within the past twenty-five or thirty years explorations and investigations of the free upper air have been actively conducted at a number of places on land. In a few instances soundings of the air have been made on the North Atlantic ocean and in waters adjacent to Europe under the initiative of the late A. Lawrence Rotch, Teisserenc de Bort, and others. As a whole, however, little is known in detail of the meteorology of the oceans, except as revealed by the simple observations of weather and wind which many merchant and naval vessels have been accustomed to report for a number of years while plying their regular

courses. Observers at sea on such occasions have but scant opportunity or incentive to engage in serious scientific observations, and difficult investigations are impossible. Consequently, what has been obtained in the past through these opportunities, and what may possibly be thus obtained in the future, is limited and restricted in every way, that is, limited as regards the kind and quantity of data that may be obtained, and restricted as to the region or locality to which it applies.

A proposal to launch and equip an expedition to make a scientific exploration of the Pacific Ocean is, therefore, hailed by the meteorologists with enthusiasm.

The aerological investigations now being made at a very few continental stations by means of kites and balloons constitute but a fragment of the evidence and data needed to exhibit the more detailed features of the circulation of the atmosphere. Data from and over the ocean can be obtained only by means of *vessels devoted exclusively* to scientific investigations, and the vast stretches of the Pacific, dotted with its occasional islands that afford useful vantage points as bases of reference, offer a field for such explorations unsurpassed elsewhere.

To state the proposal and indicate the objects of the exploration seem to be all that is necessary to enlist the fullest support thereof. It offers to meteorology the only opportunity possible to obtain full and complete observational data prepared by experienced and competent observers qualified to conduct the difficult exploration of the free air now so much needed. With the few exceptions previously alluded to, upper air explorations have been made only at a small number of continental stations, located at a few points in England, France, Italy, Belgium and Germany. These, in a sense, constitute only a small group in the aggregate and are supplemented by a few additional detached points of observations in the United States.

Both the surface and the free air observations from the ocean are valuable in themselves as supplementing the corresponding continental data, but the opportunity presented by a special expedition moving from point to point in both latitude and longitude on the greatest of all oceans permits of extending observations by the same standard methods to those regions from which the information is most valuable and most needed.

Progress in the development of our knowledge of the upper air and its general circulation awaits accurate observations by the aid of kites and balloons. The scanty observations from a few stations on limited and scattered continental areas show that the atmosphere arranges itself in two or more well-defined layers of different characteristics and

extent. Little is known and much is as yet conjectured as to the real boundaries, dimensions, and characteristics of these several strata, even over land areas. Only an expedition like that proposed can suffice to extend such studies to our greatest ocean and over which there is every reason to suppose the atmosphere disposes itself in its best defined, simplest and most orderly arrangement because an ocean represents an almost unlimited extent of level and uniform surface conditions, accompanied by stable and uniform gradients of temperature and other meteorological conditions. The modifying effects experienced at land stations due to their elevation above the sea, their local topographic environment, and other disturbing causes are wholly absent or inappreciable over the ocean, whence marine observation may be expected to supply, not only a kind of data the meteorologist greatly needs, but the best data of that particular kind.

By the aid of suitable recording instruments carried aloft by balloons we may obtain, if the instruments are recovered, a record of the temperature, pressure, and moisture of the air, the sunshine, and possibly some other conditions. However, as a free balloon simply drifts along with the air strata through which it rises and falls, no record of the *motion* of these strata can be procured from the balloon itself. To ascertain the *motions* we must continuously triangulate the successive positions of the balloons. This calls for two or more observers, with appropriate theodolites, located at the ends of a suitable base line. Such observations are often not even attempted as a part of aerological work, but they are indispensable in studies of the circulation of the upper air. No other observations are more urgently needed in meteorology at the present time than these, and it is difficult to conceive of a better field for conducting such observations on a broad and all-inclusive plan and scale than the Pacific Ocean. These motions of the free air, in conjunction with the pressure and temperature thereof, are the data most needed to verify or disprove, or rather, if possible, to adapt and apply Ferrel's general theories to the motions of the air as they may be actually observed on an expedition of the kind proposed.

Emphasis has been laid upon the aerological work which a Pacific exploration could perform, because the need for this is greater, perhaps, than for any other phase of meteorological investigation, and also because the expedition provides such exceptionally favorable opportunities for its prosecution. Nevertheless, the complete study of surface conditions, the observation of clouds, fogs, waterspouts, auroras and lightning, including the photographing of such phenomena, and the intensive study of the inception, development,

progress and decline of typhoons and similar marked storms constitute a program of work that claims the careful attention of those who plan the expedition, and can not fail to command the interest and approval of men of science generally.

ON THE DISTRIBUTION OF PACIFIC INVERTEBRATES

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The distribution of Marine invertebrates is important, as one of the keys to the former distribution of land masses, and to our very imperfect knowledge of their distribution in the Pacific. Certain species, usually those inhabiting the reefs and comparatively shallow water, are very widely distributed over the region usually referred to as Indo-Pacific; but when a careful collection of the species belonging to any isolated island or group is available it becomes evident that a large proportion of them are local and combine to form a local fauna. A knowledge of these faunas is necessary before any satisfactory discussion can be had of the presumably Tertiary fossiliferous deposits which are found fringing the more elevated Pacific islands. The landshells of the Hawaiian and Tahitian groups indicate a high antiquity for their isolation according to Pilsbry, the most eminent student of these animals. The facies of the Tertiary fossils obtained by Ochsner on the Galapagos Islands indicates a derivation from the American rather than the Indo-Pacific fauna, with which the recent invertebrates are commingled. These facts indicate the interest which attaches to a wider knowledge of the Pacific faunas.

THE MARINE ALGAE OF THE PACIFIC

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In considering the desirability of an exploration of the Pacific Islands the following points relating to our knowledge of the marine algae of the Pacific may be mentioned. Our present knowledge is so fragmentary that it is not possible as yet to suggest any special problem of a general nature whose solution would be aided by a well arranged expedition. What the important general questions are we cannot tell until after a more thorough exploration has given us a more detailed knowledge of